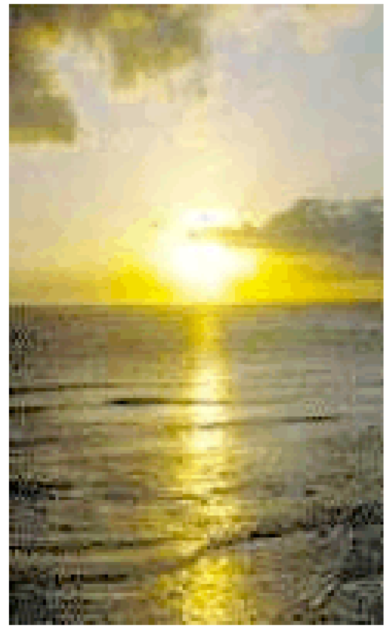
The Sun

Teacher led discussion on the Sun as the source of energy and particles.

Time:

30+ Minutes



Content Standards:

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry
- Identify questions and concepts that guide scientific investigation
- Formulate and revise scientific explanations and models using logic and evidence
- Recognize and analyze alternative explanations and models
- Understandings about scientific inquiry
  - Physical Science – Content Standard B
    - Structure of atoms
    - Structure and properties of matter
    - Motions and forces
    - Interactions of energy and matter

Objective:

This unit's purpose is to provide the foundation for understanding the connection between space weather and geomagnetic storms. Students will be introduced to terminology related to the Sun and will complete several activities designed to enhance terminology comprehension. This material could be introduced with the questions: What is space weather? Where does the energy and matter for "space weather" come from?

The objective is not to get bogged down in a major discussion and work on learning all the details of the Sun's structure. The main idea is to build an understanding that the Sun is not simply a large simple "burning ball". Rather, it is a very complex, structured object, in which nuclear reactions in the core area provide the energy that everything in the solar system is affected by and that large amounts of material are continually ejected, creating the "solar wind". Somewhat regularly, large events happen on the Sun that lead up to larger ejections, which in turn lead to the events that are analogous to storms in our space weather system.

Presentation of pictures should include information brought by the teacher, comments and questions from the students in an open forum type setting. The teacher may want to do more research.

Equipment, Materials, and Tools:

Background:

The Sun is a star. Although it looks very different to the stars we see it night, it is one of 100 billion stars in our galaxy alone. It is considered a rather ordinary star, classified as a yellow dwarf, but is in the top 10% of all stars by mass.

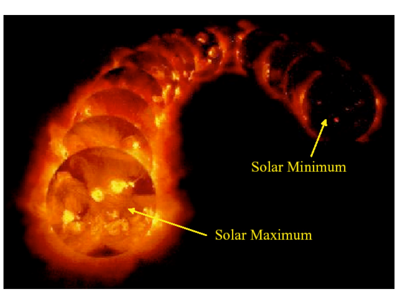
The Sun is located in a rather quiet neighborhood of space. It lies some 32,000 light-years (32,000 X 9 trillion km) from the center of our galaxy. The Sun's period of revolution around the galactic center takes 225 million years. It is about 4.5 billion years old and has used up about half of the hydrogen in its core. It will continue to peacefully radiate for another 5 billion years when it will eventually run out of hydrogen fuel causing radical changes that will result in the total destruction of the terrestrial planets and probably creating a planetary nebula.

The Sun is the largest object in the Solar System, containing more than 99.8% of the total mass (1.989^{30} kg)of the Solar System. It's diameter is 1,390,000 km. The temperature at the Sun's core is 15,600,000 K^{o}, while at its surface it is 5800 K^{o}. The Sun at present is made up of about 75% hydrogen and 25% helium by mass, everything else amounts to only 0.1%. This changes slowly over time as the hydrogen is converted to helium in the Sun's core.

Scientists have seen that features on the Sun appear to move from one side to the other. This is because the Sun actually rotates. The Sun's rotation period is approximately 27 Earth days. The Sun actually demonstrates differential rotation: at the equator it rotates once every 25.4 days while near the poles it is as much as 36 days. This is due to the fact that the Sun is not a solid body. Similar effects are seen in the gaseous planets.

The Sun emits energy as different electromagnetic wavelengths. Each wavelength can be viewed with different types of instruments, one being our eyes. The wavelengths visible to our eyes are referred to as the 'visible light spectrum' that is comprised of seven colors: red, orange, yellow, green, blue, indigo, and violet. Invisible to us are wavelengths shorter and longer than the visible spectrum and can be seen only with special instruments.

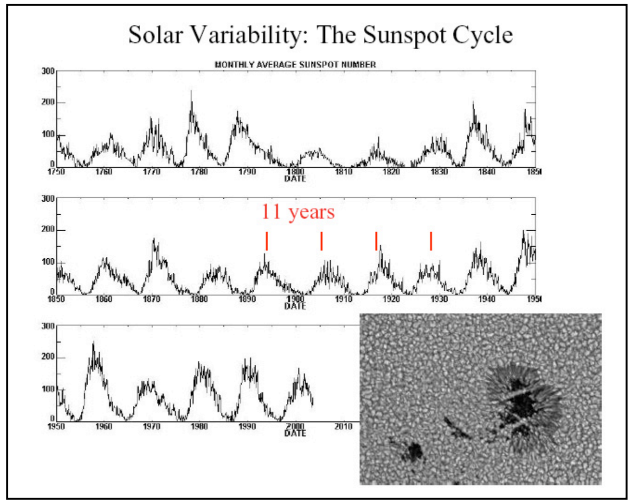
Scientists look at the Sun with special instruments that are designed to see only specific colors of light, even the wavelengths that are invisible to our eyes. The Sun looks different, depending on which wavelengths we choose to view. Scientists are able to describe the different layers of the Sun by viewing different wavelengths of light from the Sun. The layers most easily seen are the photosphere, the chromosphere, and the corona.

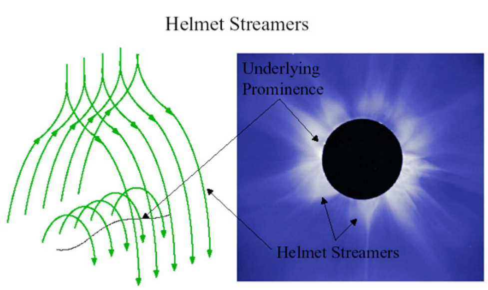


The corona of the Sun, the outermost layer, is a real puzzle. We can see the corona only when the photosphere has been occulted (blanked out), i.e., a solar eclipse or mechanically induced eclipse. The only way the corona can be studied is through the use of X-ray sensing instruments. X-ray images show scientists the parts closer to the Sun.

The corona is the only layer that is hot enough to emit X-rays. It is millions of degrees hotter than the surface of the Sun.

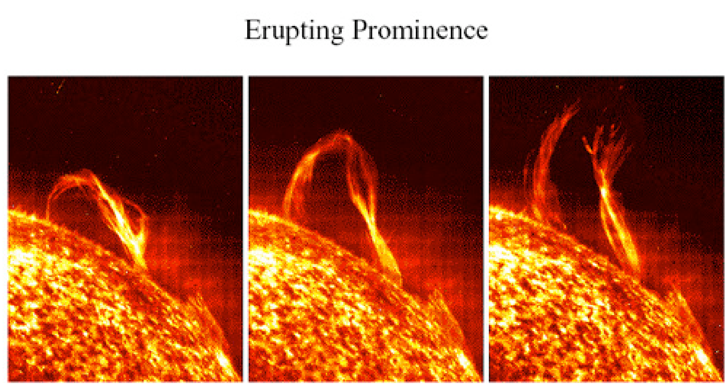
The Sun has a complex magnetic field. This magnetic field is very strong (by terrestrial standards) and very complicated. The Sun's magnetosphere extends well beyond Pluto. When matter from the Sun interacts with the field, the results are Sunspots, solar flares and coronal mass ejections. Activity on the Sun follows an eleven-year cycle when the activity increases and decreases. This period of activity is not constant but varies between 9.5 and 12.5 years. During the cycle, changes occur in the Sun's magnetic field and in the surface disturbance level. The quieter period is termed "solar minimum," while the most active time refers to "solar maximum." Periods of high activity may be associated with magnetic storms on the Earth and with other injurious effects.





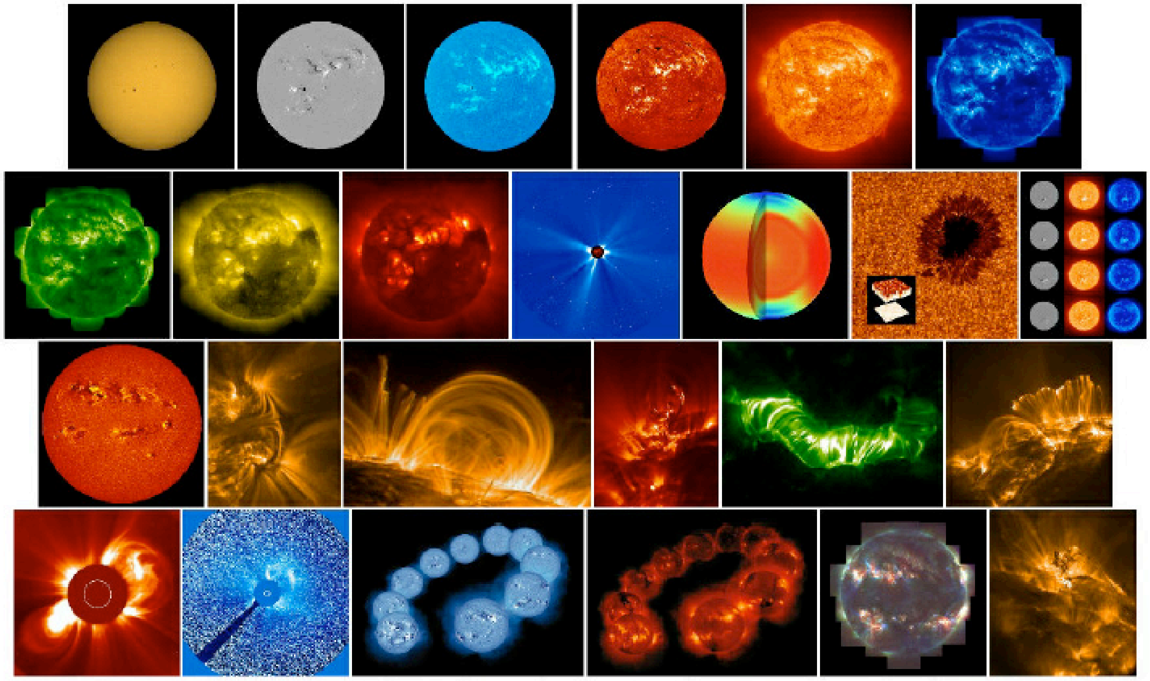
At the beginning of the solar cycle, the Sun's magnetic field resembles a dipole with its axis aligned with the Sun's rotational axis. Helmet streamers can be seen forming a continuous belt around the Sun's equator and coronal holes are seen near the Sun's poles. Towards the solar maximum period, this configuration is totally destroyed, leaving the Sun, magnetically, disorganized with streamers and holes scattered all over different latitudes.

In addition to heat and light, the Sun also emits a stream of charged particles (mostly electrons and protons) known as the solar wind. This solar wind propagates throughout the solar system and has dramatic effects on the Earth ranging from power line surges to radio interference and creates the beautiful auroras seen in the northern and southern latitudes. In addition to the solar wind, scientists have studied spectacular loops and prominences on the Sun's surface.



Our Sun provides an exciting 'laboratory' in which to do experiments. Scientists are able to investigate its behavior with various instruments from space as well as from Earth.

The following activities will explore sunspots, solar flares, and coronal mass ejections (CME's). They are designed to instill a greater understanding of the Sun and its affects on the bodies within the Solar System. We have learned that we live with a very dynamic star.



Views of the Sun demonstrating its dynamic nature.